The Effect of Seagrass on the pH of Marine Environments:

How Seagrass Impacts the pH of Acidic Saltwater Solutions

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SIAD TTH 8:30-9:30

Abstract

The purpose of this experiment was to test an aquatic plant's ability to change the environment around it. This is important since water provides a safe habitat to the majority of living organisms on earth and thus any change in its chemical makeup could have dire consequences to marine life. While there exist many factors that contribute to the loss of marine habitats like the falling pH levels of the ocean, nature has found a way to fight back through the use of plants. Since plants have been known to decrease CO_2 in the environment, we hypothesize that they also have the ability to increase the pH of water.

In order to test our hypothesis, we measured the pH of four aquatic environments as time progressed. All four environments were created in the same way except for one, the control, which lacked the presence of an aquatic plant (Cyperus Helferi). italicize After about a week of daily data collection we saw a positive trend in the pH level as time progressed. The rate at which pH increased followed a logarithmic trend, as it increased quickly and then leveled off.

Using a statistical test (ANOVA) we were able to conclude that the plants created a significant change in the pH of the water as predicted. All three plants were able to raise the pH of the water to a comfortable level for other marine life.

Introduction

In the past century, the ocean's standard pH level of 8.2 has dropped to an overall pH of 8.1, resulting in shoreline areas with pH levels falling below 7.4 (Garrard et al., 2014). The lingering effects of this rise in water acidity is now grouped within the term "Ocean Acidification," or the overall lowering in the pH of the world's oceans (Garrard et al., 2014). Marine systems are feeling the detrimental impact of ocean acidification, which, after having traced this rise in acidity to the start of the industrial revolution, has been a direct result of increasing carbon dioxide levels in the atmosphere (Brewer, 2013). Large quantities of anthropogenic carbon dioxide have been absorbed by the oceans, causing an increase in dissolved inorganic carbon molecules within ocean water and a subsequent change in ocean carbonate chemistry (Garrard et al., 2014).

When carbon dioxide from the atmosphere dissolves into the ocean, it creates carbonic acid, which causes a drop in pH (Garrard et al., 2014). These lower pH levels have the potential to disrupt marine ecosystems, especially those populated by shelled organisms and invertebrates (Wittmann & Portner, 2013). Calcium carbonate minerals are the building blocks for calcifying organisms to build their shells and skeletons (Balmer, 2014). With the acidification of the oceans, these "building blocks" are less available, affecting the ability of shelled organisms to access calcium carbonate in order to make and maintain their shells.

Is there a way for shelled organisms and other marine life to escape some of the current acidifying pressures of the ocean? In recent observations, marine biologists have observed the number of invertebrates in different areas of a coral reef. Scientists have found that there were significantly larger numbers of invertebrates in areas with an abundance of seagrass and other marine plants (Garrard et al., 2014). Seagrasses naturally supply organisms with nutrients and shelter, which is a possible reason for the increasing numbers of shelled organisms within these areas (Garrard et al., 2014). However, marine plants and seagrasses are also known for absorbing high quantities of atmospheric carbon dioxide dissolved in the water and subsequently producing other carbon products, such as carbonate. In fact, seagrass meadows take up less than 0.2% of the area of the world's oceans, yet bury more than 10% of total carbon stores (Fourqurean et al., 2012). If, indeed, seagrasses provide the ability to absorb carbon dioxide while releasing products such as carbonate (a molecule essential for invertebrates), is it possible that seagrass attracts invertebrates by providing necessary minerals? This is a reasonable possibility, however, with shoreline regions falling to pH levels of 7.4 and lower, the highly acidic water may still be too detrimental to crustaceans and echinoderms, organisms known for living in coastal regions, especially seagrass meadows. If seagrass could possibly raise the pH, then perhaps invertebrates will be more likely to live in such an area so that ocean acidification will not dissolve their shells and skeletons. It was hypothesized that seagrasses would indeed raise the pH of an aquatic environment (tank), with the null hypothesis being that no pH change would occur within the controlled marine environment. The following experiment was set up to determine whether, amongst other factors, seagrass could potentially raise the pH of marine environments.

Materials and Methods

Three plastic aquarium tanks, with dimensions 10 x 8 x 6 inches that could hold approximately 2.5 liters of liquid, were used as the habitats for the seagrass, Cyperus Helferi, while a fourth tank of dimension 8 x 6 x 4 inches was used as a control tank. All three tanks with the seagrass must be given similar living conditions in order to compare to a fourth tank, the control tank, that lacks a seagrass plant. These conditions include a saltwater solution that was created with a mixture of deionized water, a pH of 7, and Instant Ocean Aquarium Salt. For every one liter of deionized water, 30 grams of salt were appropriately mixed with a stir bar and later a magnetic stirrer in order to form the desired saline solution that is most suitable for the seagrass. In the three aquatic tanks with the seagrass, two liters of the saline solution must be added in order to completely submerge the seagrass in the tank. The seagrass also requires a substrate (Api Root Tabs) that is used to introduce food, trace minerals, and desired nutrients for the plant in order to help best mimic a natural habitat for the seagrass. Finally, a thin layer of aquarium gravel at the bottom of the tank is helpful in order to anchor the seagrass to the bottom of the tank and to help avoid the seagrass from floating loosely inside the tank. The control group holds similar conditions to these aquatic tanks, but it lacks a seagrass plant. The control group is present in order to test whether the seagrass truly does increase pH levels of water in the three tested tanks compared to the control tank. Using an electronic pH meter, data was recorded for all four tanks in order to observe any changes in the pH of the water. After recording the pH, the aquatic tanks were placed under a light source and data collection was repeated for five days.

Results

All three tanks containing seagrass (tanks 1, 2, and 3) had a higher change in pH than the control tank (See Figure 1). The mean pH values for tanks 1, 2, and 3 were 7.756, 7.702, and 7.608, respectively (See Figure 2). The control tank had a mean pH value of 7.262. A One-Way Correlated Anova test was performed on the data in order to test for significance, and a p-value of 0.000188 was found, showing overall significance and accepting the original hypothesis (See Table 3). Due to this result, post-hoc tests were run, and in this case, a Tukey HSD test was used to compare the significance of the results between tanks. This test showed that all three seagrass tanks differed significantly with the control tank, but did not differ significantly with each other (See Figure 3). This result showed that each experimental tank (or trial) gave consistently higher pH vales than the tank that contained no seagrass. There is evidence to suggest that the original hypothesis (that seagrass would raise the pH of a marine environment) could have statistical significance. Thus, there is a greater-than-chance possibility that seagrass indeed raises the pH of seawater.

Table 1: pH Value of Tanks

Day	Tank 1	Tank 2	Tank 3	Control
1	7.54	7.2	6.94	6.84
2	7.64	7.55	7.5	6.97
3	7.77	7.83	7.87	7.45
4	7.84	7.98	7.87	7.47
5	7.99	7.95	7.86	7.58

Figure 2: pH per Day

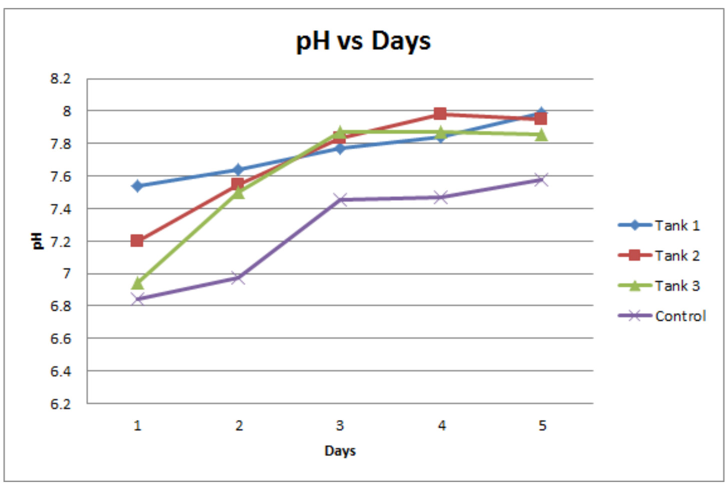

Figure 1: Mean pH Values

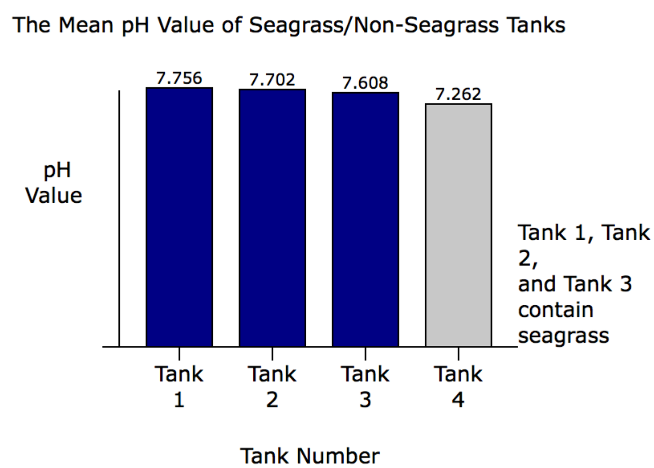

Table 2: Data Means, Variance, Error, and Deviations

Data Summary						
	Samples					
	1	2	3	4	5	Total
N	5	5	5	5		20
ΣX	38.78	38.51	38.04	36.31		151.64
Mean	7.756	7.702	7.608	7.262		7.582
ΣX^2	300.8998	297.0343	290.067	264.1263		1152.1274
Variance	0.0305	0.1076	0.1647	0.1108		0.1259
Std.Dev.	0.1747	0.328	0.4058	0.3328		0.3549
Std.Err.	0.0781	0.1467	0.1815	0.1488		0.0794

Table 3: Anova Error and P-Value

standard weighted-means analysis					
ANOVA Summary	Correlated Samples k=4				
Source	SS	df	MS	F	P
Treatment [between groups]	0.7388	3	0.2463	15.68	0.000188
Error	0.1881	12	0.0157		
Ss/Bl	1.4661	4			
Total	2.3929	19			

Figure 3: Significance Between all Tanks

Tukey HSD Test

HSD[.05]=0.24; HSD[.01]=0.31
M1 vs M2 nonsignificant
M1 vs M3 nonsignificant
M1 vs M4 P<.01
M2 vs M3 nonsignificant
M2 vs M4 P<.01
M3 vs M4 P<.01

Discussion

As shown in the results, the experimental seagrass tanks raised the pH level of the seawater significantly more than the control (no seagrass) tank. Due to the consistent readings among each experimental tank (or trial), this experiment's results may show promising reason to believe that seagrass, among other aquatic plants, is beneficial for marine organisms due to its alkalizing abilities.

A possible reason for why the seagrass raised the pH of its surrounding marine environment goes back to an instrumental process within all plants—photosynthesis. Photosynthesis is the process in which energy and carbon dioxide is converted into carbohydrate molecules (used as chemical energy for the plant itself) and oxygen. These oxygen molecules have the potential to interact and combine with the hydrogen protons given off by the dissolved inorganic carbons ("Dissolved Oxygen," 2010). This produces hydroxide (OH-), which may produce very strong bases when combined with elements often found in seawater, such as sodium, calcium, and other trace elements. Thus, seawater within close proximity of a seagrass patch or meadow may show signs of a more basic solution.

How might this be important for shelled organisms and invertebrates? An increased concentration of dissolved oxygen within areas surrounding seagrass meadows aid organisms' aerobic respiration. Oxygen helps creatures and microorganisms respire, releasing carbon dioxide back into the environment, which can later be used by the seagrass to build minerals ("Dissolved Oxygen," 2010). When there is a lack of dissolved oxygen, marine animals (especially microorganisms) are forced to anaerobically respire, which consequently gives off the byproducts methane and ammonia ("Dissolved Oxygen," 2010). These byproducts contribute to an ensuing increase in acidity within the seawater ("Dissolved Oxygen," 2010). Thus, the vicious cycle of acidic waters becoming more acidic continues. With seagrass introduced to an ecosystem, however, it could potentially buffer the consequences of ocean acidification. So why might crabs, invertebrates, and other shelled creatures prefer seagrass habitats? First, access to seagrass also grants them access to vital and necessary carbonate, a key ingredient for forming shells and skeletons. Next, seagrass meadows and regions have a higher level of dissolved oxygen that may aid aerobic respiration in marine life. Finally (as shown in this experiment), seagrass has the potential to create a slightly more basic environment that could possibly prevent sea creatures' shells from dissolving and lessen the strain put on the marine organisms by the ever more acidic seas.

It should be noted, however, that all parts of this experimental design were not completely accurate. The pH meter used in this experiment had certain difficulties, such as sometimes-false acidic readings. Also, The tank used for the control was half the size of the experimental tanks (although proportionally, the substrate complex and seawater concentration were equivalent). This could have led to a slight bias in the results. However, the same pH meter was used for the entirety of the experiment as to make the experiment consistent. Even with these problems, the results still managed to be overwhelmingly significant, even with the standard error factored into the statistical reasoning.

Overall, the seagrass in each tank did, significantly, raise the pH. Although more experiments should be run, this idea has potentially noteworthy results. Seagrass could conceivably be used as a pH buffer for coastal regions to prevent rock erosion, as well as to prevent the loss of species caused by an increasingly acidic environment. Ensuring that these coastal seagrasses and plants are conserved could, perchance, help reverse the negative consequences that increased carbon emissions have had on the world's oceans.

Citations

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Responsibilities

Throughout the project [redacted] was in charge of initial research on the topic and finding out all the things needed to make the project work. This included ordering the plants and setting up lab times. He was also delegated the creating of the work medians such as the power point presentation and word documents for the group. [redacted] wrote the Abstract section as well as the Responsibilities section of the lab report.

[redacted] on the other hand managed the hands on experiment as in measuring the actual pH of the water and creating the saltwater solutions. She was also in charge of obtaining any missing materials needed during the experiment. Along with [redacted], she completed the statistical analysis and graphs for the presentation/paper, and filled in the slides of the power point. [redacted] did the Anova part of the statistical analysis, as well as the tables/graphs that were related to Anova. She wrote the Introduction, Results, and Discussion sections of the report.

Finally, [redacted] had the task of preparing the tanks for the experiment and making sure that the plants were taken care of. He also was in charge of editing the presentation/report. Additionally he created the basis for the experimental design. Last but not least he was the chief recorder, meaning he took the pictures of the experiment for the presentation and recorded everything that was done during the experiment. He wrote the Materials and Methods and the Citations sections of the report.